

## Structure and Properties of Atoms

**PS-2 The student will demonstrate an understanding of the structure and properties of atoms.**

**PS-2.7 Explain the consequences that the use of nuclear applications (including medical technologies, nuclear power plants, and nuclear weapons) can have.**

**Technology Level:** 2.7-B Understand Conceptual Knowledge

### **Key Concepts:**

Nuclear medicine

Nuclear power reactors

Nuclear weapons

**Previous/Future knowledge:** Students were introduced to the process of nuclear decay in PS-2.2 and to fusion and fission in PS-2.6. PS-1.7 requires that Physical Science students can evaluate technology on the basis of designated criteria. As South Carolina is a major player in the United States nuclear program, it is important that students can understand and evaluate nuclear applications.

**It is essential for students to understand** that the term “consequences” refers to both those that are negative and those that are positive. They also need to understand that nuclear decay occurs naturally in many elements that are common on earth, and there is always some radiation present in every environment. The degree to which radiation is harmful to living organisms depends upon the type of radiation and the quantity of radiation to which the organism is exposed.

**Students need to understand the identified nuclear applications in the indicator:**

### ***Nuclear medicine***

Understand that radioactive materials are used in medical technologies.

- Examples of benefits might include:
  - o Using radiation that results from the decay of certain isotopes to destroy targeted cells, such as cancer cells.
    - Cells are most susceptible to damage from radiation during the process of cell division. As cancer cells divide at a very fast rate, they are destroyed in greater numbers than normal cells, which divide less often.
  - o Using the radiation that results from the decay of certain isotopes as a way of mapping the path of various substances through targeted organ systems.
    - Most substances that naturally pass through specific body systems can be “tagged” with radioactive samples of the same substances. The radioactivity can then be traced (using a Geiger counter, photographic film, or computers with “gamma cameras”) as the “tagged” substance naturally makes its way through the targeted body system thus revealing how the body system is functioning. In this manner, the natural functioning of the body system can be observed.
- Examples of possible drawbacks might include:
  - o Waste from nuclear medicine must be stored in a special way until it is no longer radioactive.
  - o Radiation treatment directed at cancerous cells will also cause some damage to healthy tissue. Newer radiation treatments seek to minimize the damage to the healthy tissue while still destroying the cancerous tissue.

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### *Nuclear weapons*

Understand that some fission and fusion nuclear reactions can be used in weapons.

- Examples of benefits might include:
  - Some people believe that nuclear weapons are a deterrent to war.
- Examples of possible drawbacks might include:
  - Specialized technology is required to refine the fuel and to produce the weapons.
  - Tremendous amounts of energy available from small amounts of fuel so smuggling is possible.
  - The potential for a tremendous amount of destruction, both material and biological.
  - Contamination of the environment with fission-product isotopes, many of which are radioactive and remain so for very long periods of time.
  - Waste from the production of nuclear weapons must be stored in a special way until it is no longer radioactive, which can be a very long time.
  - Nuclear waste must be transported from where it is generated to where it will be stored, which very often involves passing through populated areas.
  - Improper handling of nuclear materials and possible leakage can cause radioactive isotopes to contaminate the environment, causing long-term radioactive decay problems.

### *Nuclear-power reactors*

Understand how nuclear technology is used to produce electricity

- Energy from controlled nuclear fission is used to heat water into steam,
  - The steam expands turning a turbine which spins a huge magnet within a coil of metal wire
  - The moving magnetic field forces electrons to flow in the metal wire.
- The primary difference between a coal-powered electric generating plant and a nuclear-powered electric generating plant is the method of heating water; the other processes in the sub-bullets above are the same in both types of power plants (see PS-6.11 Generators).
- Examples of benefits might include:
  - Tremendous amounts of energy available from small amounts of fuel
  - No greenhouse gas or other air pollution from the burning of fossil fuels
  - Can be used anywhere (as opposed to wind power, solar power, hydroelectric power, etc)
  - Abundance of fuel
  - Non-reliance on fossil fuel
- Examples of possible drawbacks might include:
  - Requires specialized technology to refine the fuel.
  - Can cause thermal pollution to water systems.
  - Waste from nuclear fission reactors must be stored in a special way until it is no longer radioactive, which can be a very long time.
  - Nuclear waste must be transported from where it is generated to where it will be stored which very often involves passing through populated areas.
  - Improper handling of nuclear materials and possible leaks can cause radioactive isotopes to contaminate the environment, causing long-term radioactive decay problems.
  - Accidents in poorly designed or poorly maintained facilities, such as Chernobyl or Three Mile Island.
  - Exposure of workers in nuclear facilities to radiation.

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### Assessment Guidelines:

The objective of this indicator is to explain consequences of nuclear applications, therefore, the primary focus of assessment should be to construct cause and effect models that show both the beneficial effects that the nuclear reaction has in meeting a need or producing a product and the possible drawbacks that might result from the process.–

In addition to *explain*, assessments may require students to

- Exemplify a nuclear application;
- Summarize major points about one of the applications listed;
- Recognize the benefits or drawbacks of nuclear power.